Storm *integrated* Water Management

for North Central Texas

North Central Texas Council of Governments

# System Design Methodology

Alan Greer

Freese & Nichols

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# Project Purpose

Providing a comprehensive guideline for

## Integrated Storm Water Management

throughout the planning, design, construction, operation and maintenance of storm water infrastructure

A recent technical review of the interactions between land use, transportation and environmental quality identified six characteristics of the built environment associated with beneficial environmental results:

- ✓ Compact development
- ✓ Mixed land uses
- ✓ Transit accessibility
- ✓ Support of pedestrian & bicycle activity
- ✓ Safeguarding of environmentally sensitive areas
- ✓ Reduced impervious surfaces & improved water detention

From: *Our Built and Natural Environments*

# The sixth characteristic

- Impervious surfaces which represent the imprint of land development on the landscape
  - ✓ It is composed of two primary components
    - The rooftops under which we live
    - The transport system (roads, driveways, parking lots) that we use to get from one rooftop to another
  - ✓ Transport related impervious surfaces comprise about 2/3rds of the total
- Water detention which represents a particular aspect of storm water management systems necessitated by impervious surfaces

# Impacts resulting from increased impervious surfaces and inadequate storm water management systems

- Loss of natural areas
  - ✓ Streams, prairies, wooded areas, habitat
- More sources of pollution in runoff
  - ✓ Oils, grease, sediment, etc.
- Heightened flooding risks
  - ✓ More runoff, uncontrolled downstream impacts

# Storm Water Management *integrated*

iSWM

for North Central Texas

is

a cooperative cost-shared initiative of over 55 local governments that through the assistance of a Freese & Nichols lead consultant team is addressing these impacts for the region

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# Storm integrated Water Management

iSWM

for North Central Texas

## is

- partnerships with state & federal agencies to meet regulatory requirements
- guidelines for organizing a successful community storm water management program
- an innovative site development approach for addressing both storm water quantity & quality
- a framework for ongoing cooperative initiatives

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# Project Team

**NCTCOG**

**Program Director**
Alan Greer, PE

**Community/Governmental Relations**
Robert Herchert
Michael Nichols, PE
Alan Plummer, Jr., PE, DEE

**Technical Advisory Committee**
James Caffey, PhD, PE
Dell Greer, PE
Andrew Reese, PE

**Project Manager**
Charles Tracy, PE

## Special Services

**Public Meetings/Informational Brochures**
Heather Hartman

**Municipal GIS Systems**
Melinda Polley

**GIS/Database Management H&H Integration**
Stephen Noe

**Web Page Development**
Gregory Conover

## CDCD Manual Preparation
Andrew Reese, PE

**Hydrology/Hydraulics**
James Caffey, PHD, PE
John Rutledge, PE
Stephen Noe, PE

**Storm Water Quality**
Jonathan Young, PE
James Caffey, PHD, PE
Trey Shanks

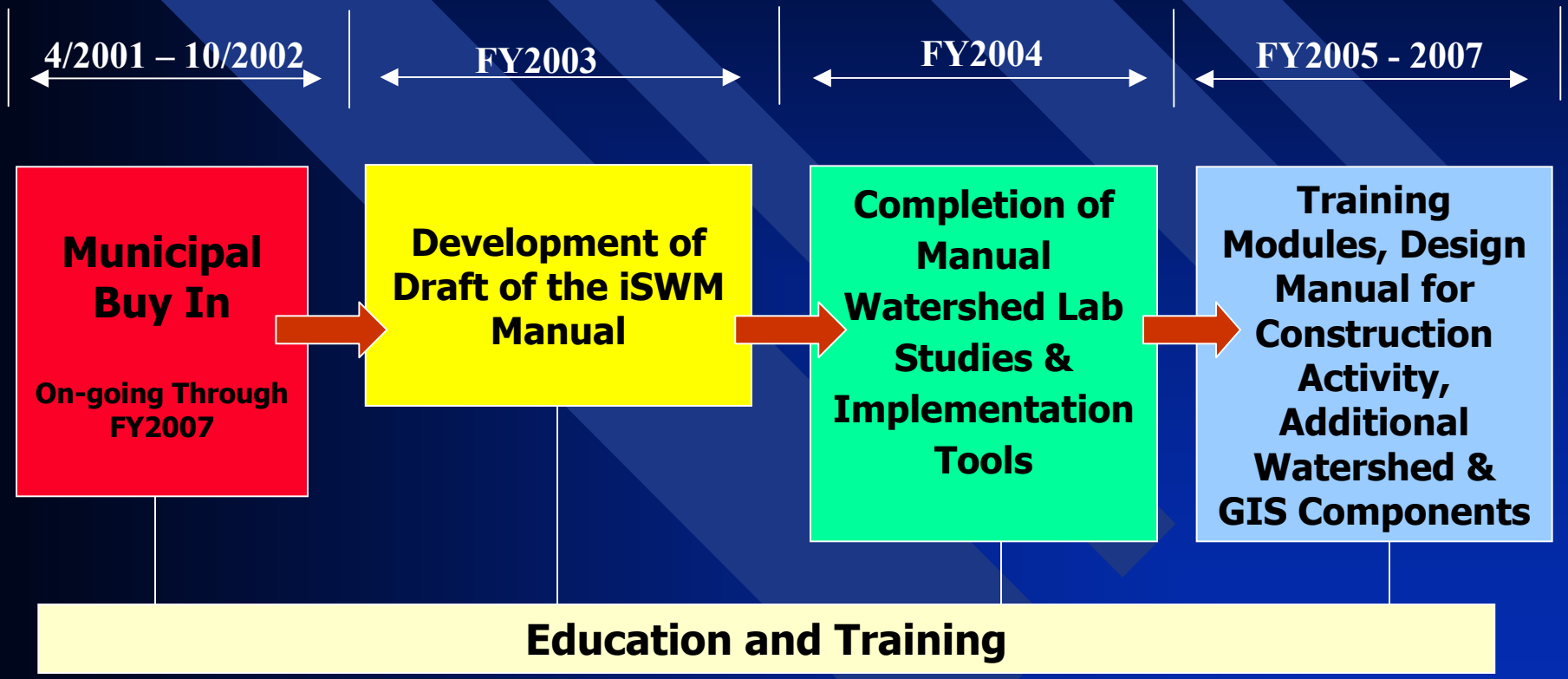
**Landscape Architecture**
Bill Cotten, ASLA

## Construction BMP Manual
Jonathan Young, PE
Trey Shanks

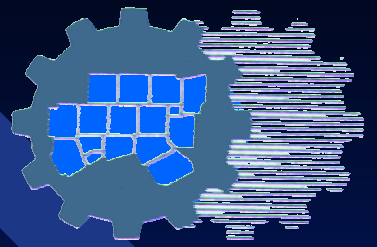
**Constructability**
Ronald Harper, PE
Larry Eckersley, PE

Freese and Nichols
Alan Plummer & Associates
AMEC
Caffey Engineering

# Five-Year Plan



# The Benefits



- Address storm water issues that cross city limits
- Improve overall storm water quality throughout the Region
- Level the playing field across the Region
- A regionally-based comprehensive drainage resource
- A “How-To” guide in storm water management for all phases of a project
- Up-to-date regulations and policies
- Standardization of processes
- User-friendly interactive on-line manual

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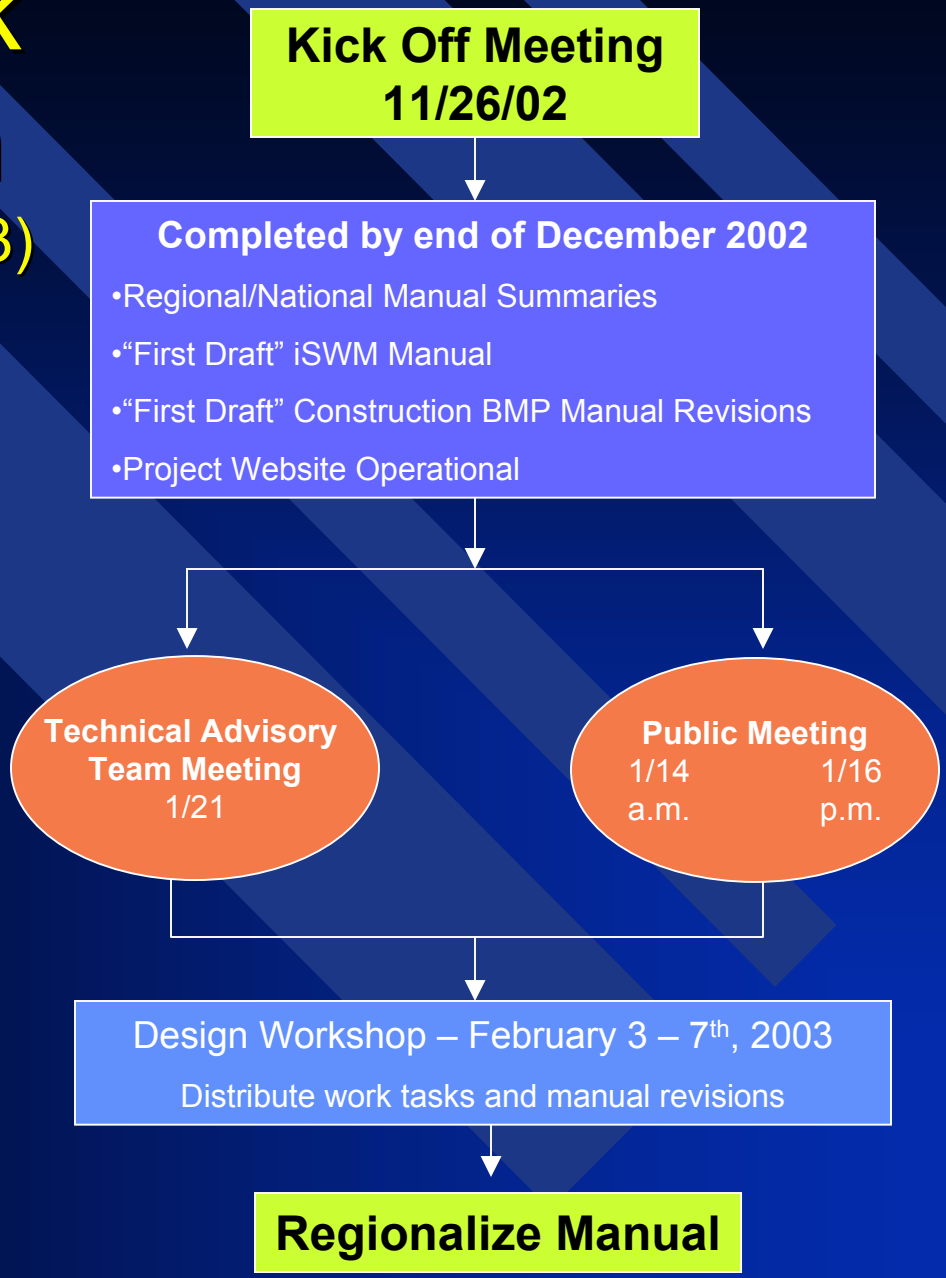
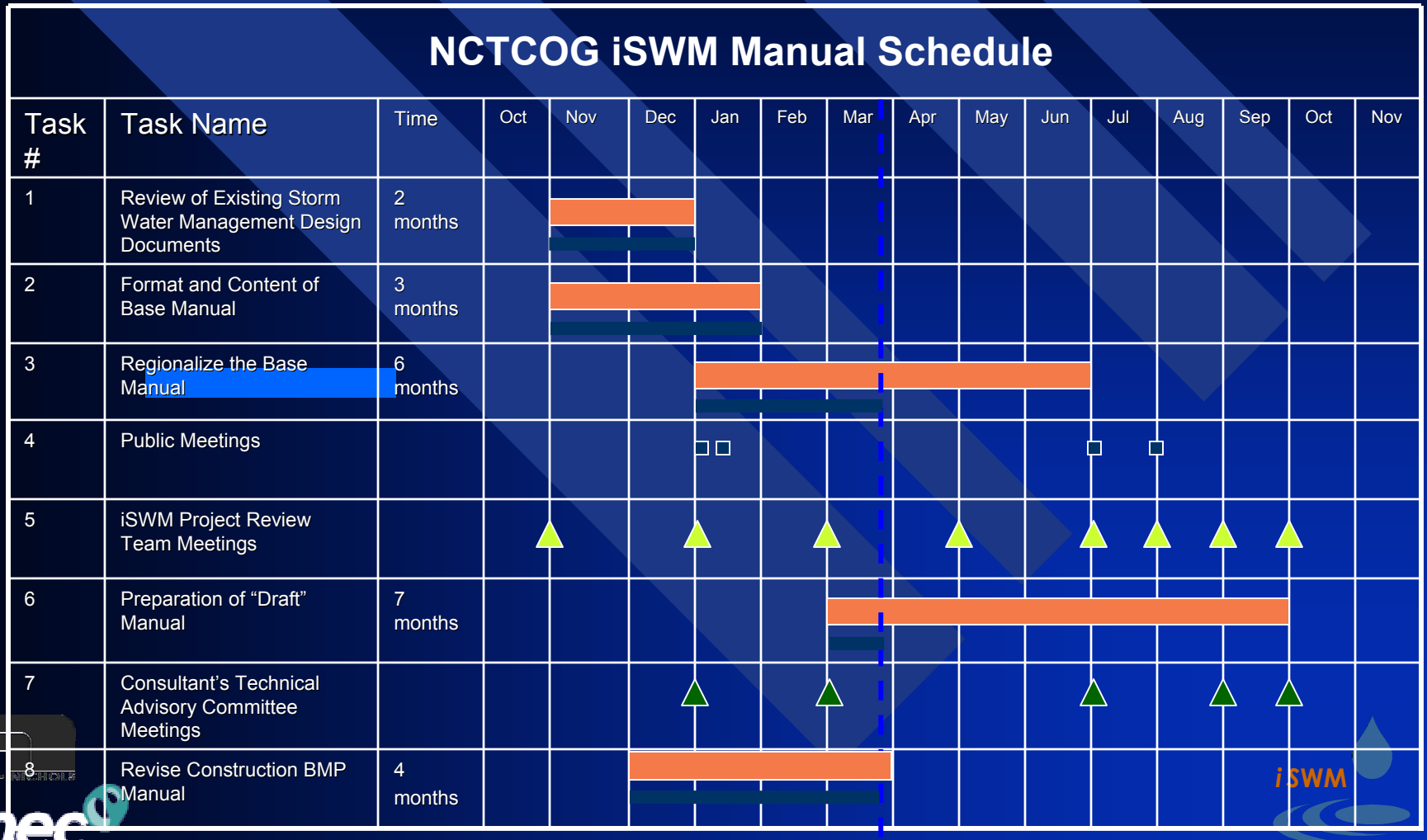
# Work Plan (FY 2003)



# Work Plan
## (FY 2003)

# Project Schedule FY 2003



# Policy Guidelines

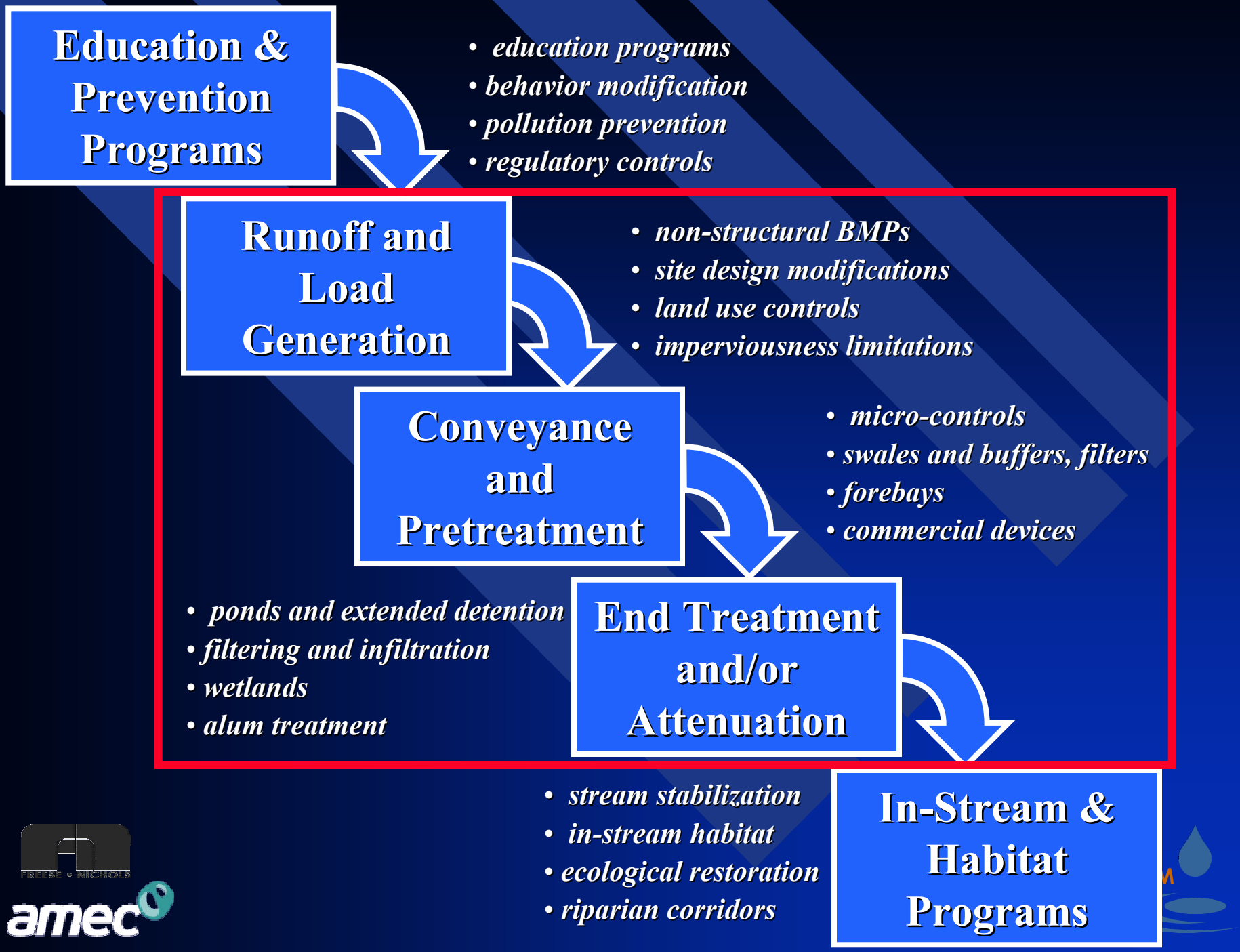
- Chapter 1 – The Case for Storm Water Management
- Chapter 2 – Partners in Storm Water Management
- Chapter 3 – Community Storm Water Programs
- Chapter 4 – Site Level System Criteria and Design
- Chapter 5 – Achieving Regional Safe, Clean and Green Goals

# Development/ Re-development Manual

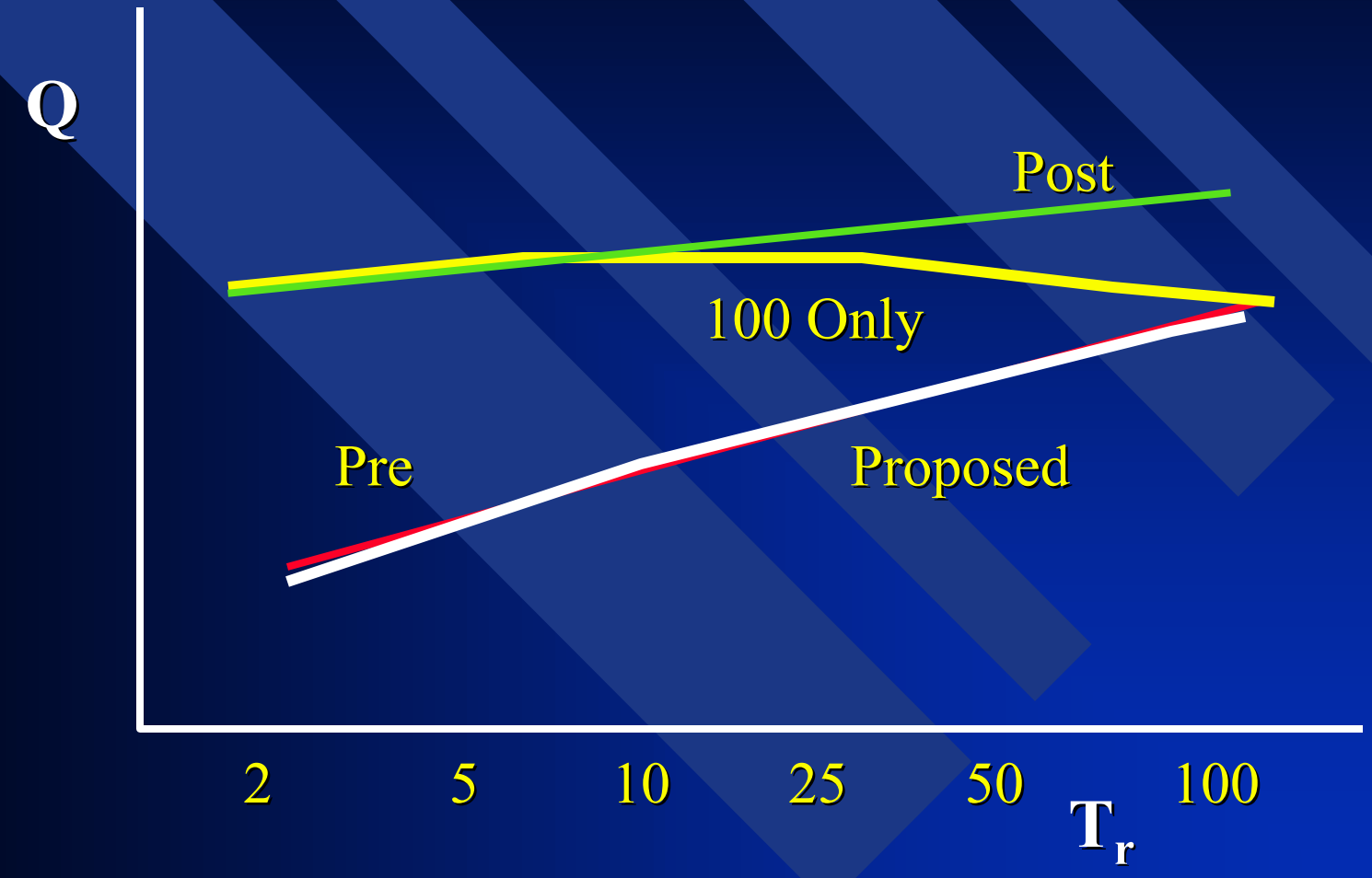
- Chapter 1 - Storm Water Management System Planning and Design
- Chapter 2 - Storm Water Hydrology
- Chapter 3 - Structural Storm Water Controls
- Chapter 4 - Structural Storm Water Controls - Conveyance

# Status

- Regional and National Manual Evaluation - Completed
- “First Draft” Red-line/blue-line Markup - Completed
- Construction BMP Manual “Draft” - Completed
- Project Website - Completed
- Public Meetings - In Progress
- Design Workshop – Completed
- Manual Production – In Progress


Education & Prevention Programs
• education programs
• behavior modification
• pollution prevention
• regulatory controls
Runoff and Load Generation
• non-structural BMPs
• site design modifications
• land use controls
• imperviousness limitations
Conveyance and Pretreatment
• micro-controls
• swales and buffers, filters
• forebays
• commercial devices
End Treatment and/or Attenuation
• ponds and extended detention
• filtering and infiltration
• wetlands
• alum treatment
In-Stream & Habitat Programs
• stream stabilization
• in-stream habitat
• ecological restoration
• riparian corridors

# Detention Policy Impacts



# Site Design Elements

## Integrated Site Design

- **Element I - Better Site Design Principles**
- **Element II - Unified Sizing Criteria**
- **Element III - Downstream Assessment**
- **Element IV - Site Design Credits**
- **Element V - Sizing of System**

# Element I
# Better Site Design Planning

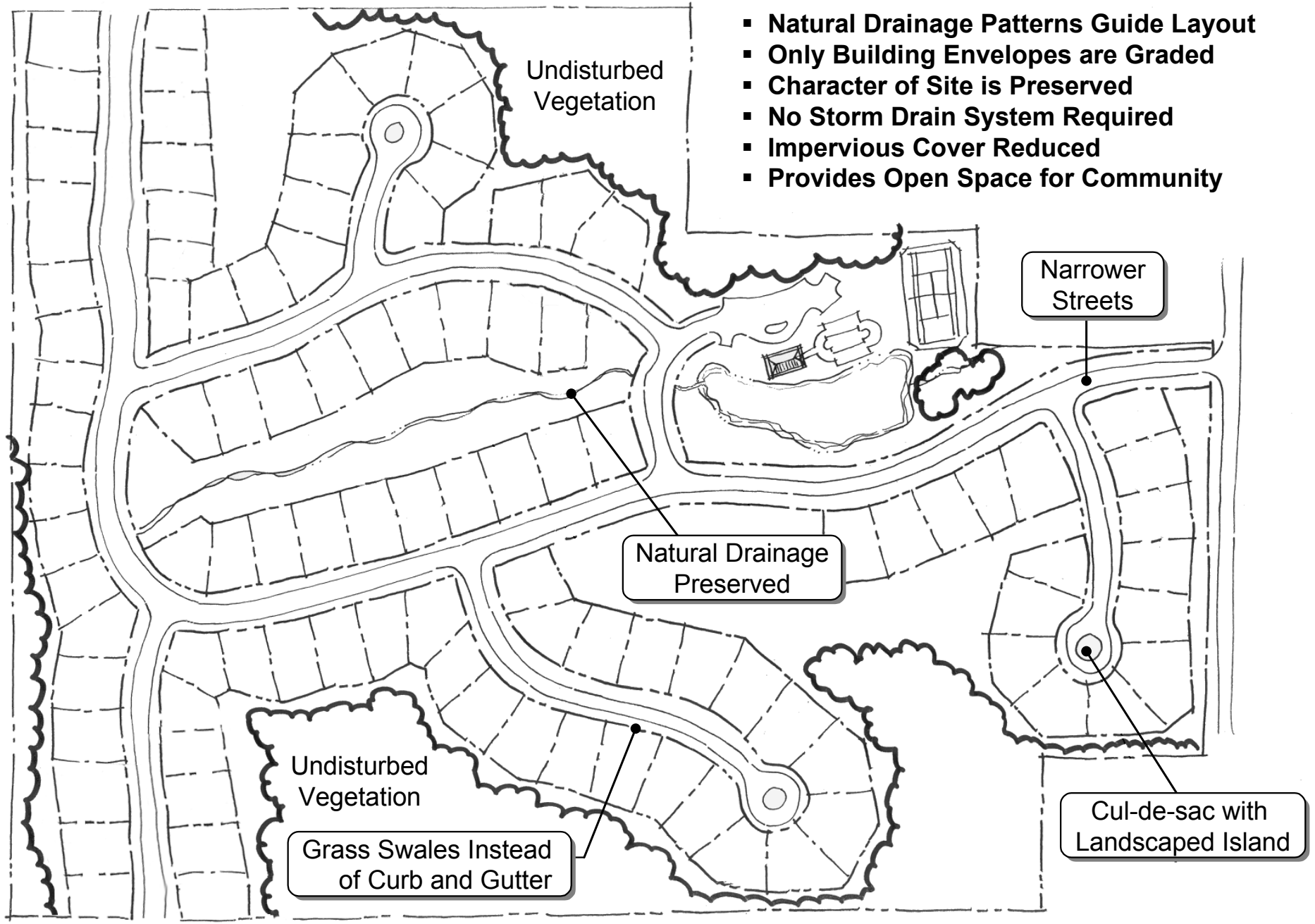
Modifying the way that development occurs so that impervious cover is reduced, natural areas are conserved, and stormwater pollution is minimized

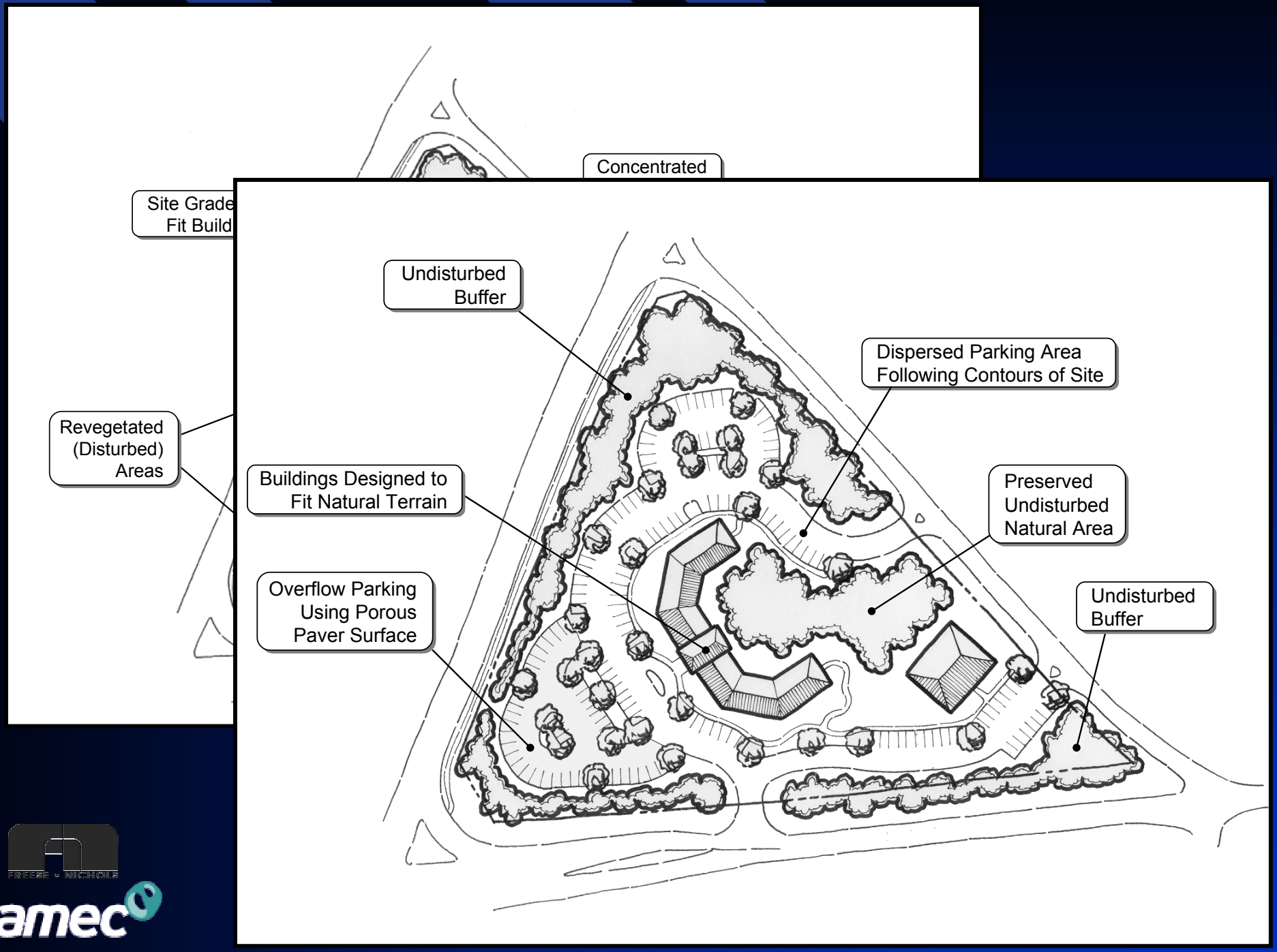
# 3 Principle Categories of Better Site Design Planning

- Conservation of natural areas
- Lower impact site layout and design approaches
- Reduction of impervious cover

- Site is Mass Graded
- Natural Drainage Patterns Destroyed
- Existing Tree Cover Removed
- Character of Site is Destroyed
- Extensive Storm Drain System Required
- Amenity Center is Only Open Space

- **Natural Drainage Patterns Guide Layout**
- **Only Building Envelopes are Graded**
- **Character of Site is Preserved**
- **No Storm Drain System Required**
- **Impervious Cover Reduced**
- **Provides Open Space for Community**



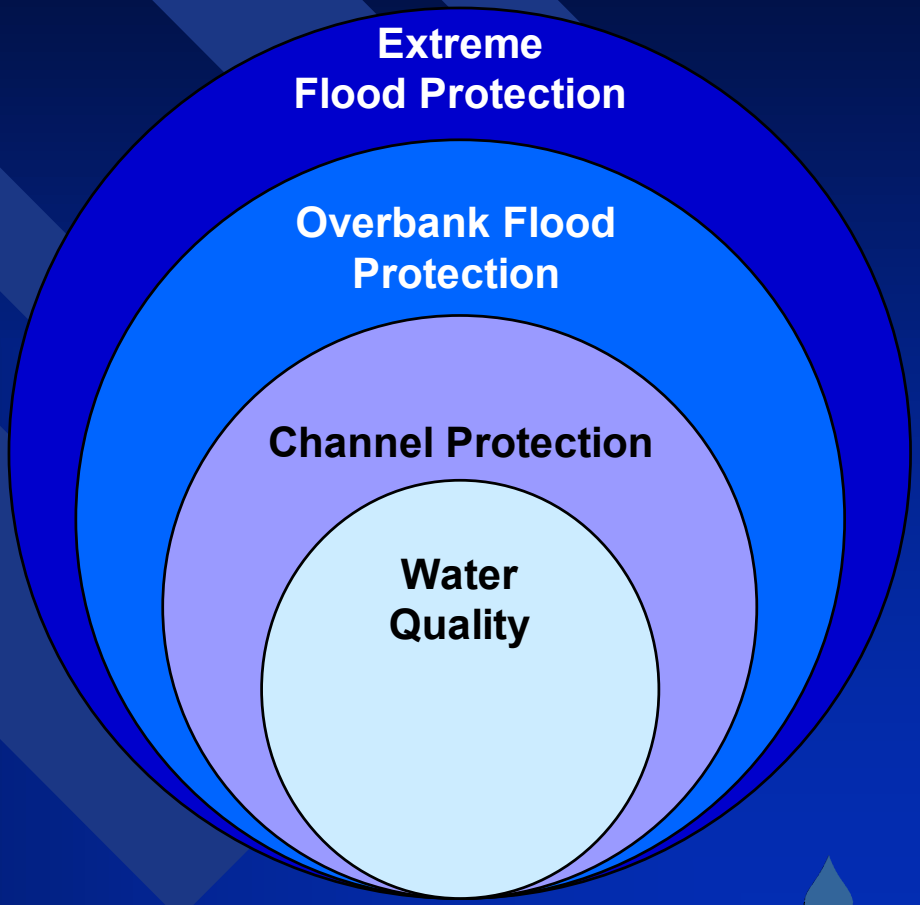

Concentrated
Site Grade
Fit Build
Undisturbed
Buffer
Dispersed Parking Area
Following Contours of Site
Revegetated
(Disturbed)
Areas
Buildings Designed to
Fit Natural Terrain
Preserved
Undisturbed
Natural Area
Overflow Parking
Using Porous
Paver Surface
Undisturbed
Buffer

# Element II
# Unified Design Criteria

Guidance on a unified approach for sizing stormwater best management practice (BMP) systems to meet flood control, pollutant removal, channel protection, and extreme flood protection objectives at new development sites.

# Unified Sizing Criteria

*A coordinated and comprehensive design methodology that minimizes the four major impacts of urban development.*



# Goal of Criteria:

- Mimic pre-development hydrologic regime by controlling runoff:
  - ✓ volumes
  - ✓ velocities
  - ✓ pollutant loads

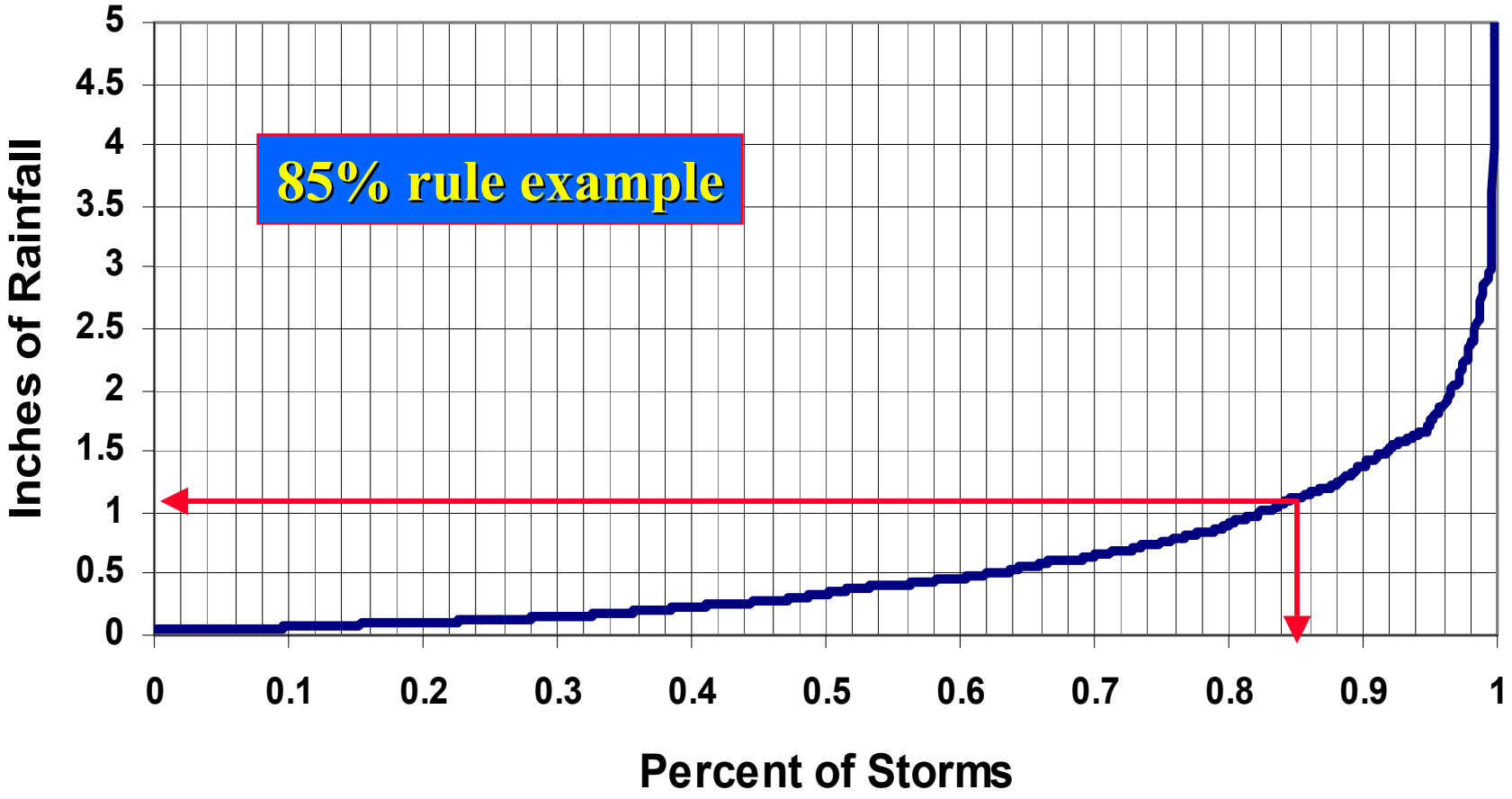
# Basic Idea:

- After better site design
- Then:
  - ✓ Reduce pollution through water quality volume
  - ✓ Reduce bank scour through channel protection volume
  - ✓ Reduce flooding through overbank volume
  - ✓ Reduce extreme event damage through extreme event volume/management
- Do this in an integrated way


Water Quality Protection

# Athens Airport

## 15 Minute, 6-Hour Storm



# Water Quality Volume

Criteria: Remove 80% percent of the annual pollutant load, as measured by TSS.

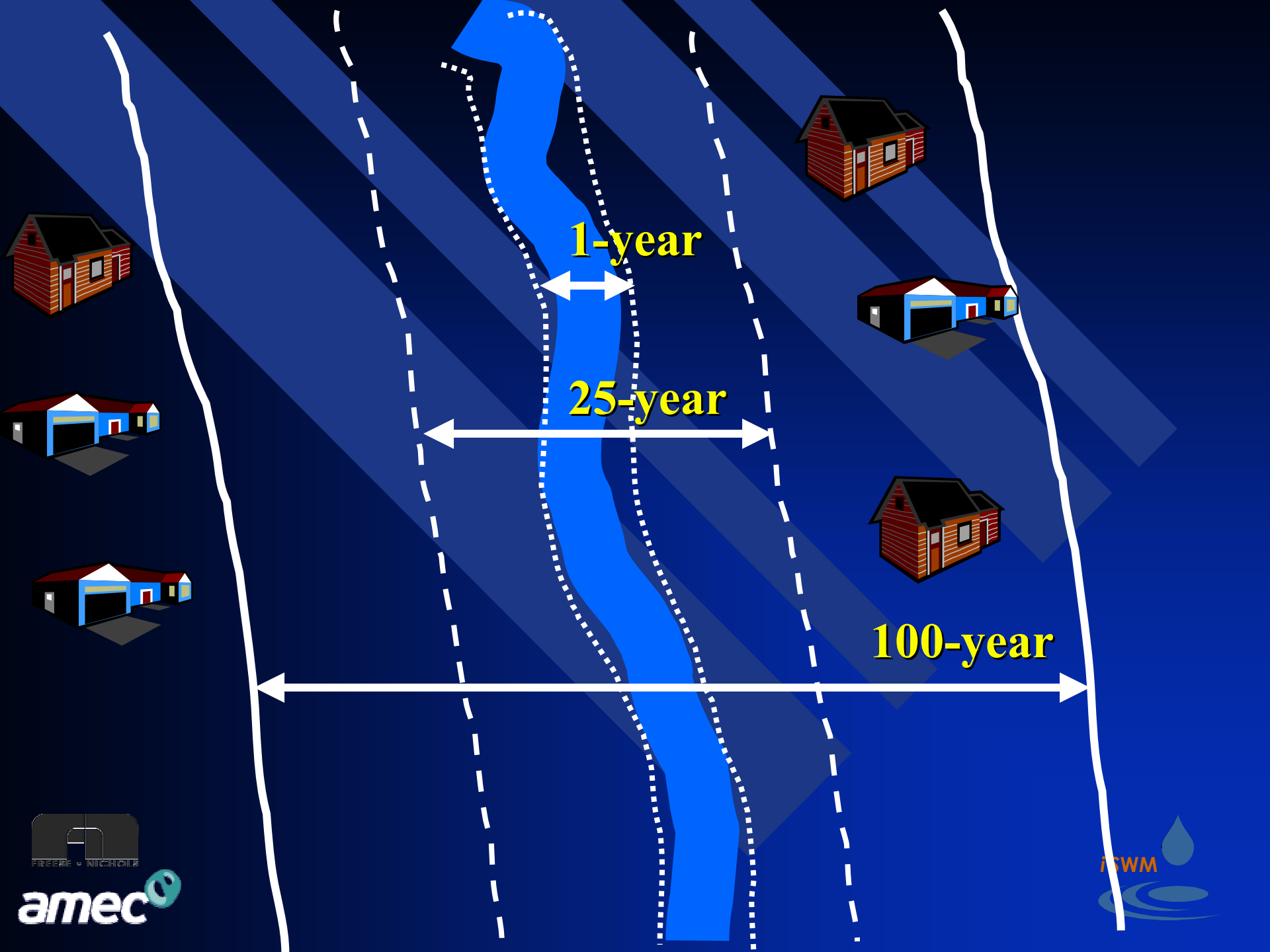
Capture and treat stormwater runoff from 85th percentile storm depth. For this region of Texas, this equivalent is being developed and will be between 1.1” and 1.6” of rainfall.

# Water Quality Volume Calculation - 85% Rule

$WQ_v = (1.2 \text{ in}) (Rv) (A)/12$

where:

| | | |
|---|---|---|
| $WQ_v$ | = | water quality volume (ac-ft) |
| 1.2 | = | $85^{th}$ % storm in inches |
| Rv | = | 0.05 + 0.009(I) |
| I | = | percent imperviousness |
| A | = | site area (ac) |


1-year
25-year
100-year

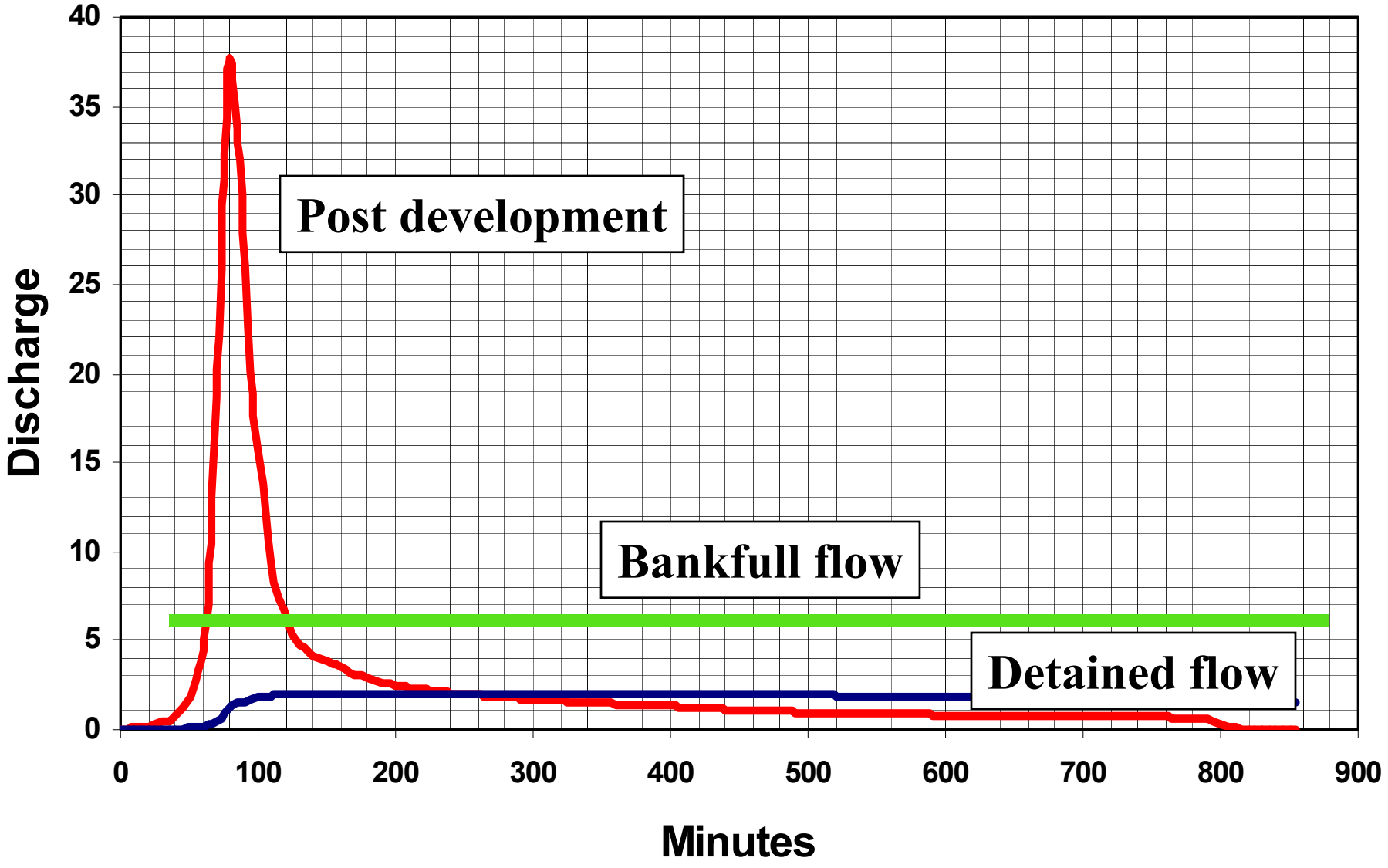
# Channel Protection

# Channel Protection Sizing

Criteria: Provide extended detention or over-control for the 24-hour, 1-year storm to protect channels from erosive velocities and unstable conditions.

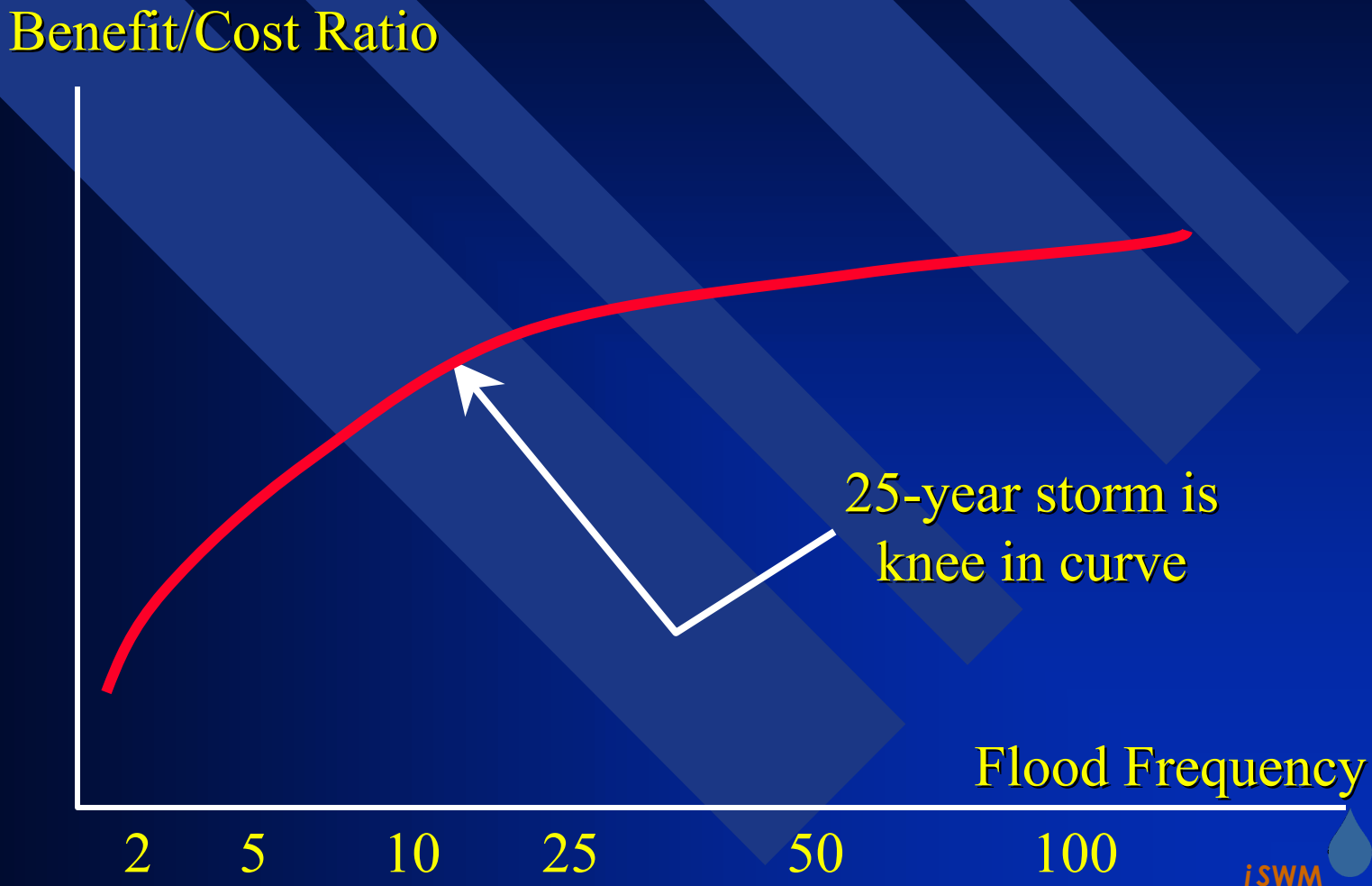
- 24-Hour extended detention of the 1-year storm event

# 1-Year Storm


Discharge
40
35
30
25
20
15
10
5
0
0
100
200
300
400
500
600
700
800
900
Minutes
Post development
Bankfull flow
Detained flow


Overbank Flooding

# Overbank Flooding



# Overbank Flood Control

Criteria: Control post-development peak discharge rate to pre-development rate for 25-yr storm event.

- ✓ Prevent increase in frequency and magnitude of out-of-bank flooding
- ✓ Keep all development out of this zone

# Extreme Flood Protection

# Extreme Flood

Criteria: Evaluate the effect the 100-year storm has on the stormwater facility, adjacent property, and downstream facilities and property.

- ✓ Prevent flood damage from infrequent but large events
- ✓ Maintain boundaries of pre-development 100-year floodplain or
- ✓ Protect at the full development 100-year level

# Wet Pond Example

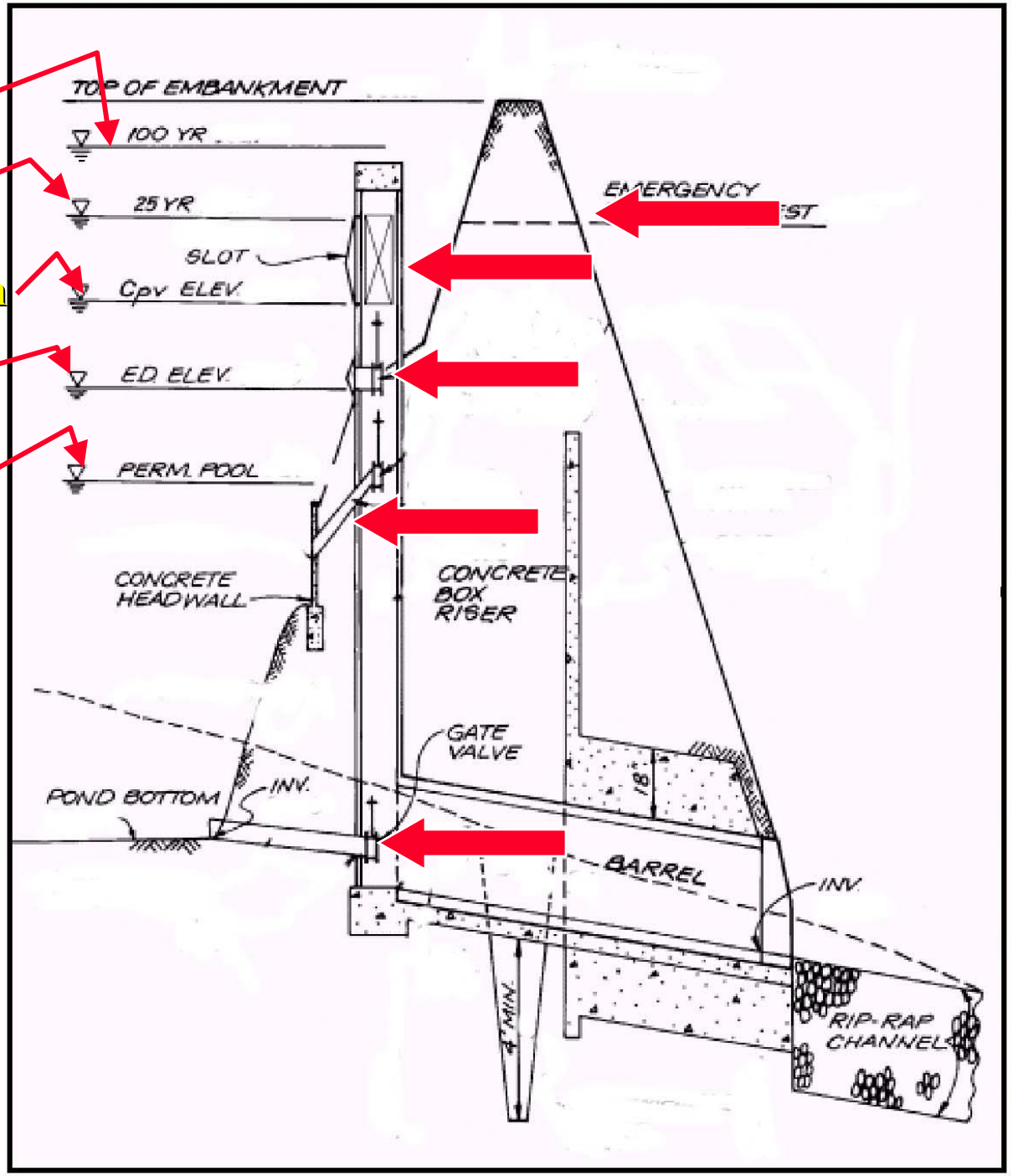
Extreme flood elevation

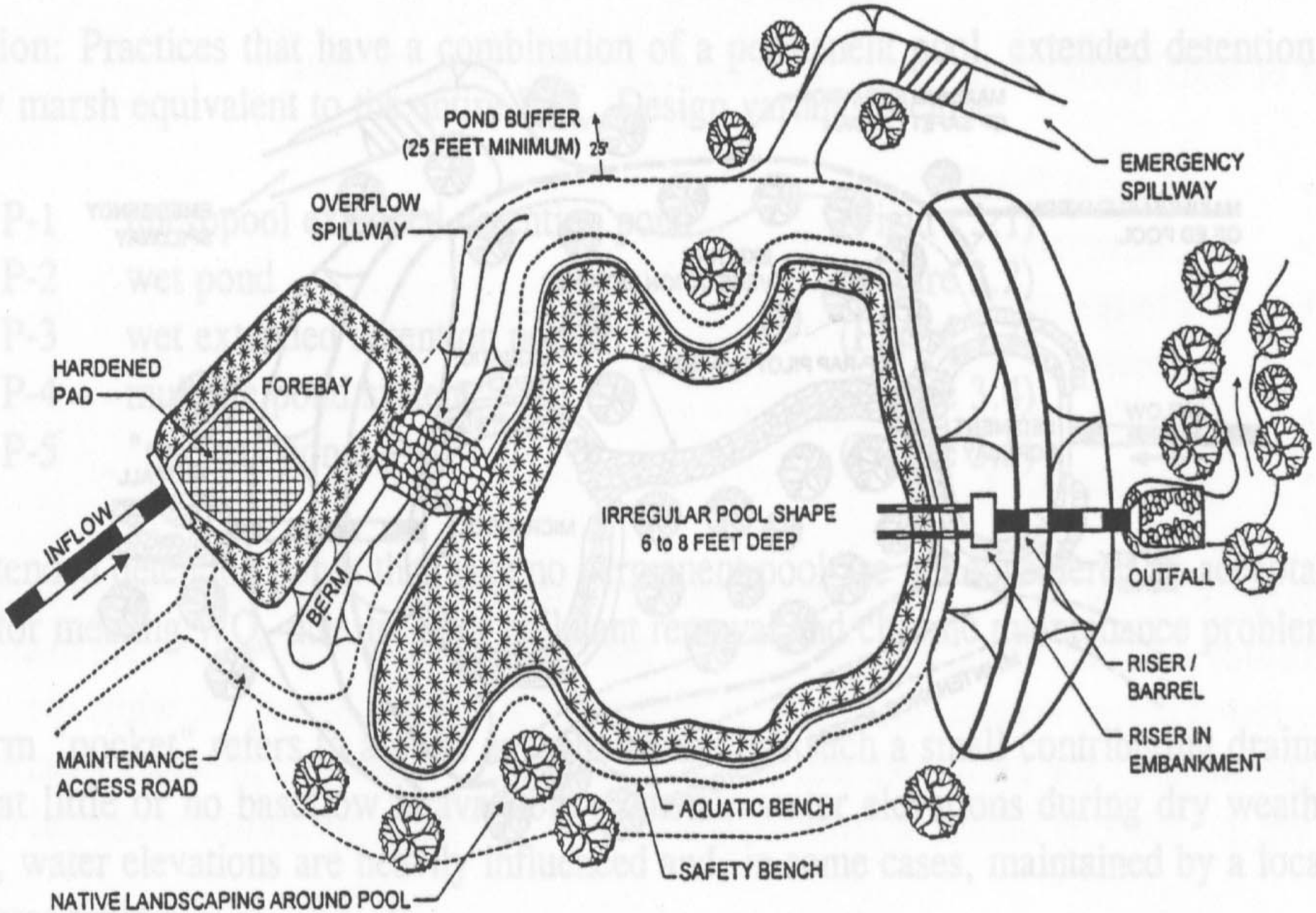
25-year flood elevation

Channel protection elevation

Water quality elevation

Permanent pool elevation




POND BUFFER
(25 FEET MINIMUM) 25'
EMERGENCY
SPILLWAY
OVERFLOW
SPILLWAY
HARDENED
PAD
FOREBAY
INFLOW
BERM
IRREGULAR POOL SHAPE
6 to 8 FEET DEEP
OUTFALL
RISER /
BARREL
RISER IN
EMBANKMENT
MAINTENANCE
ACCESS ROAD
AQUATIC BENCH
SAFETY BENCH
NATIVE LANDSCAPING AROUND POOL

**PLAN VIEW**

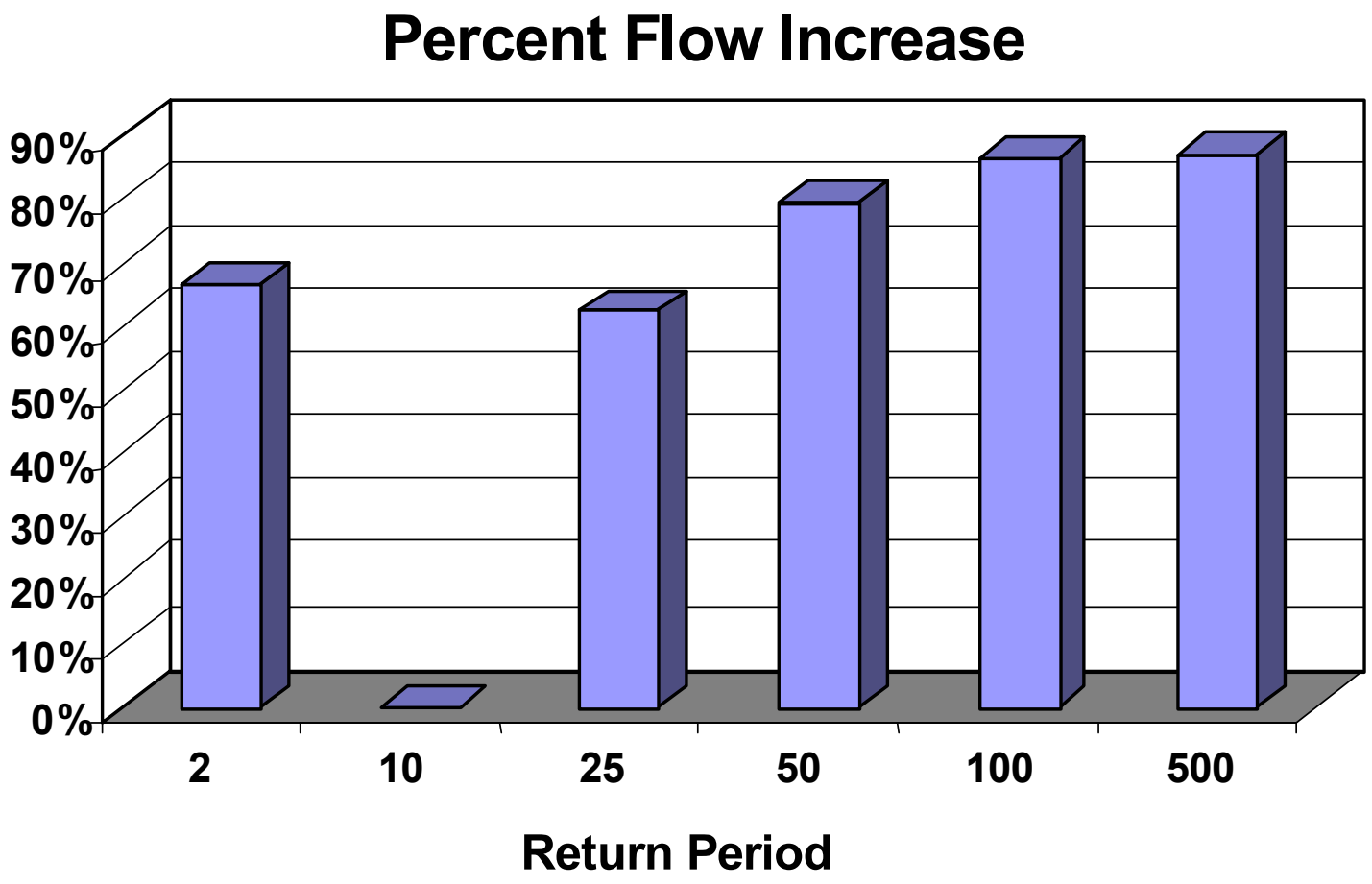
# Element III
# Downstream Assessment

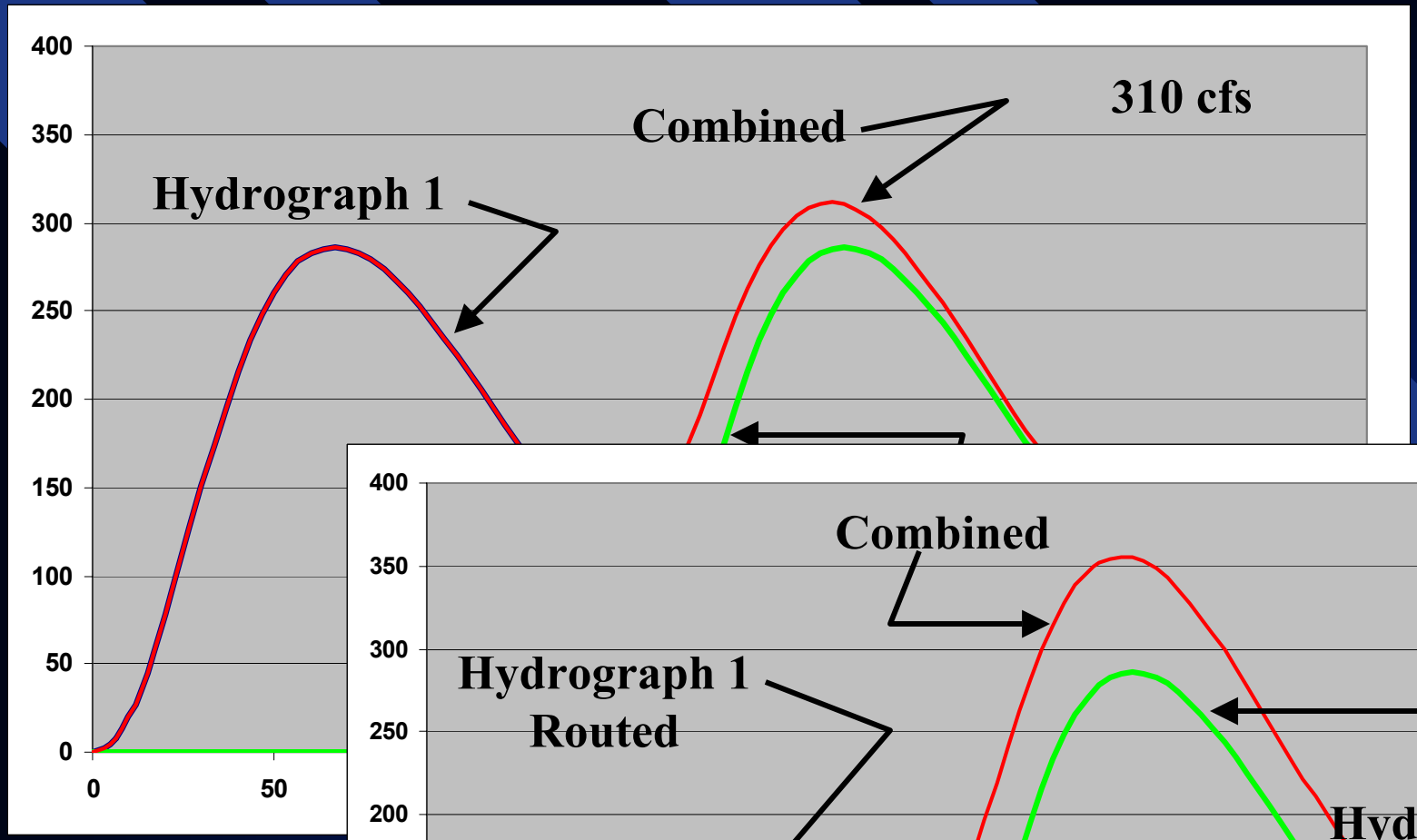
Promotion of more effective stormwater detention design through implementation of a requirement to assess potential downstream impacts of urban development

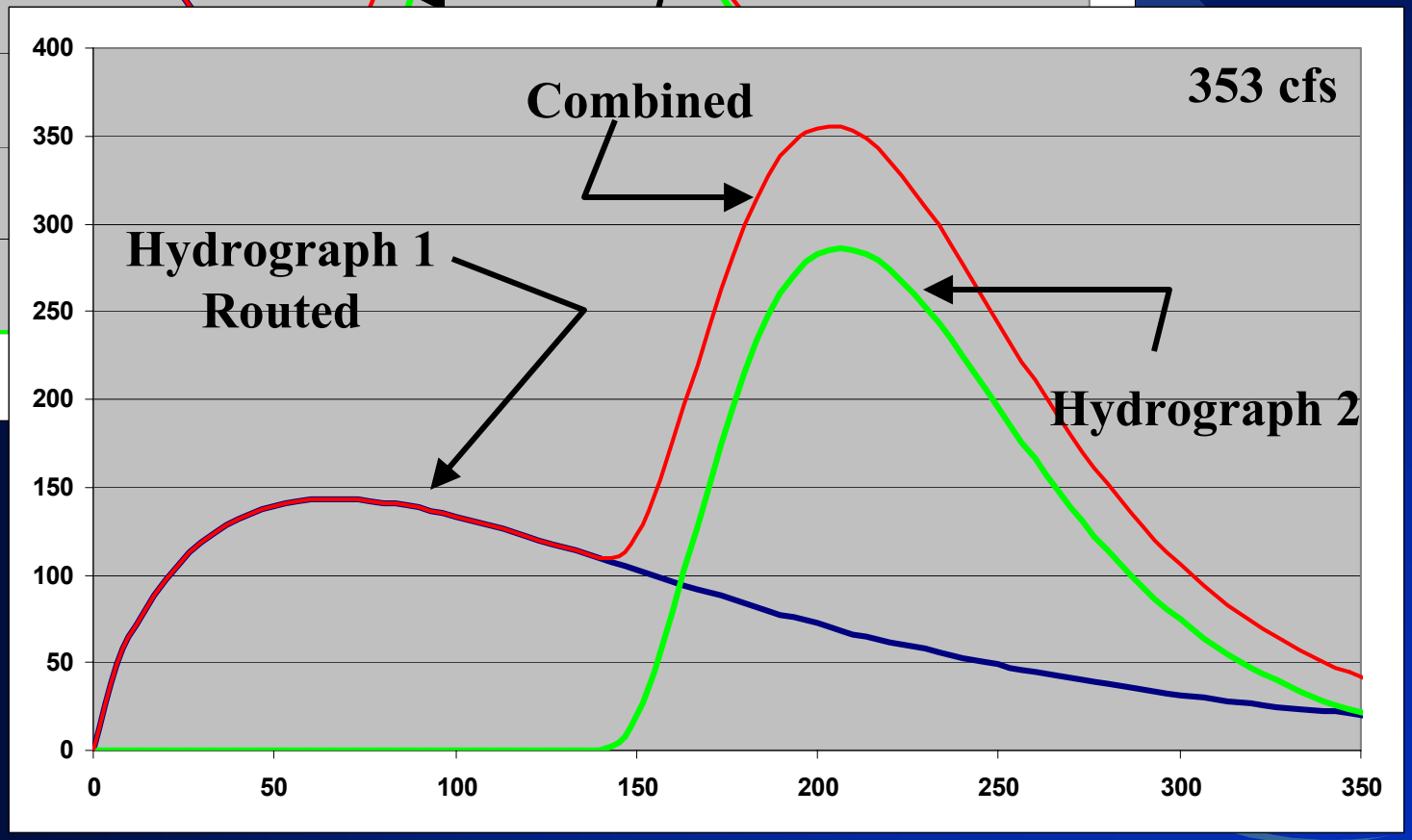
# Why Detention Ponds Fail

- Wrong design approach
- Errors in calculation
- Single design storm criteria
- Design storm too large
- Poor construction practice - outlet and low storage volume
- Poor maintenance
- Volume not considered
- Peak flow timing not considered

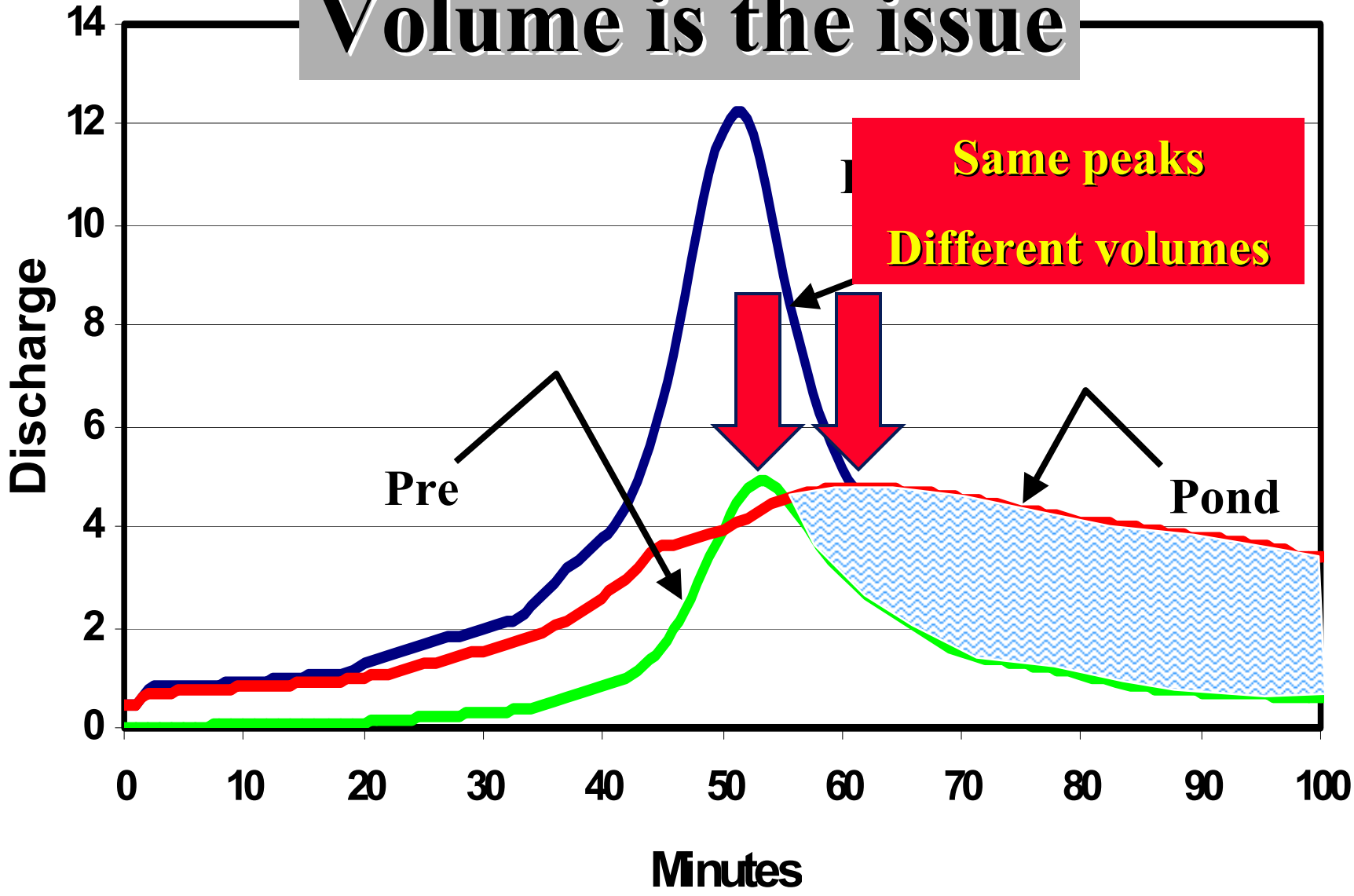
# Impact of Post=Pre 10-Year Storm at Pond Outlet - Other Return Periods



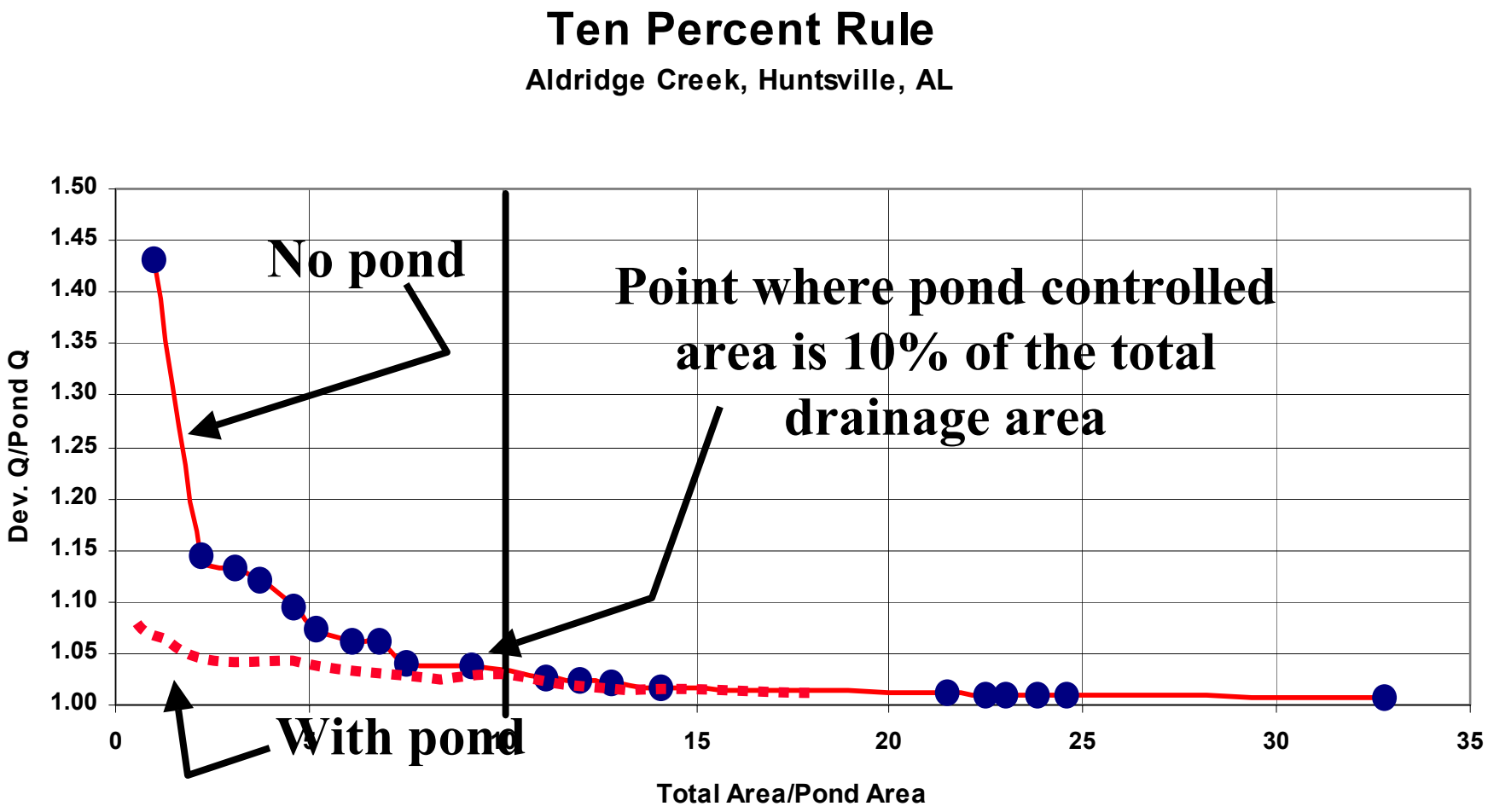

400
350
300
250
200
150
100
50
0
0
50
Combined
310 cfs
Hydrograph 1


400
350
300
250
200
150
100
50
0
0
50
100
150
200
250
300
350
Combined
353 cfs
Hydrograph 1
Routed
Hydrograph 2

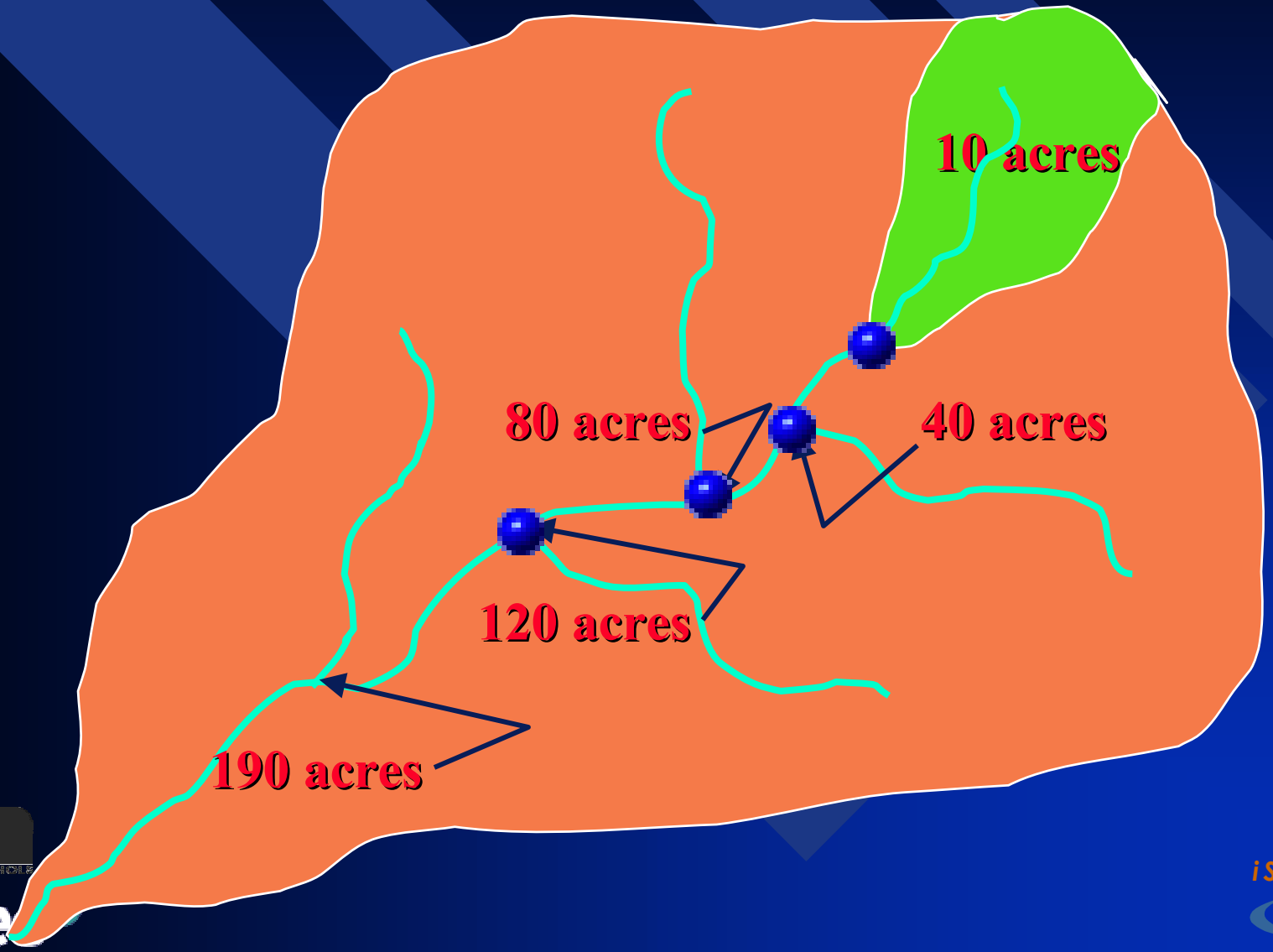
# Volume is the issue



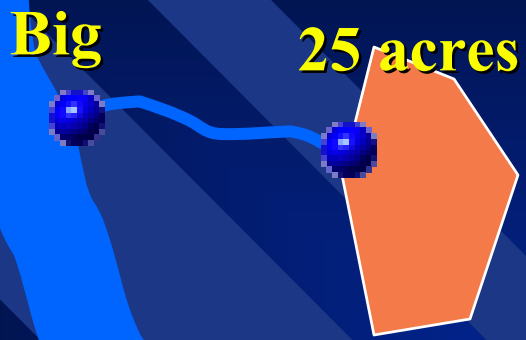
# Ten Percent Rule
## Example



# Example 1



# Example 2



# Element IV
# Site Design Stormwater Credits

Promotion of better site design and low impact development practices through the use of credits which offset a site's structural stormwater control requirements

# Credits

- Reduction of impervious cover
- Natural area conservation
- Stream buffers
- Use of vegetated channels
- Environmentally sensitive development
- Overland flow filtration/infiltration zones

# Application of Credits

- Target meeting or reducing the water quality volume requirements.
- In some cases, credits help to meet larger storm requirements by increasing times of concentrations and reducing post-development curve numbers or rational formula “C” values.

# Natural Area Conservation

- Subtract conservation areas from total site area when computing water quality volume requirements
- Post-development peak discharges will be lower due to lower post-development curve numbers or rational formula “C” values

# Natural Area Conservation Criteria

- Can not be disturbed during project construction
- Shall be protected by limits of disturbance clearly shown on all construction drawings.
- Shall be located within an acceptable conservation easement
- Shall have a minimum contiguous area requirement of 10,000 square feet.
- Shall be located on the development project.

# Natural Area Conservation Example

For a 10 ac site with 3 ac of impervious area and 3 ac of protected conservation area

Before Credit:

$WQ_v$ = (1.2 in) (0.32) (10 ac)/12 = 0.32 AF

With Credit: 3 ac of conservation are subtracted from total site area, which yields a smaller storage volume:

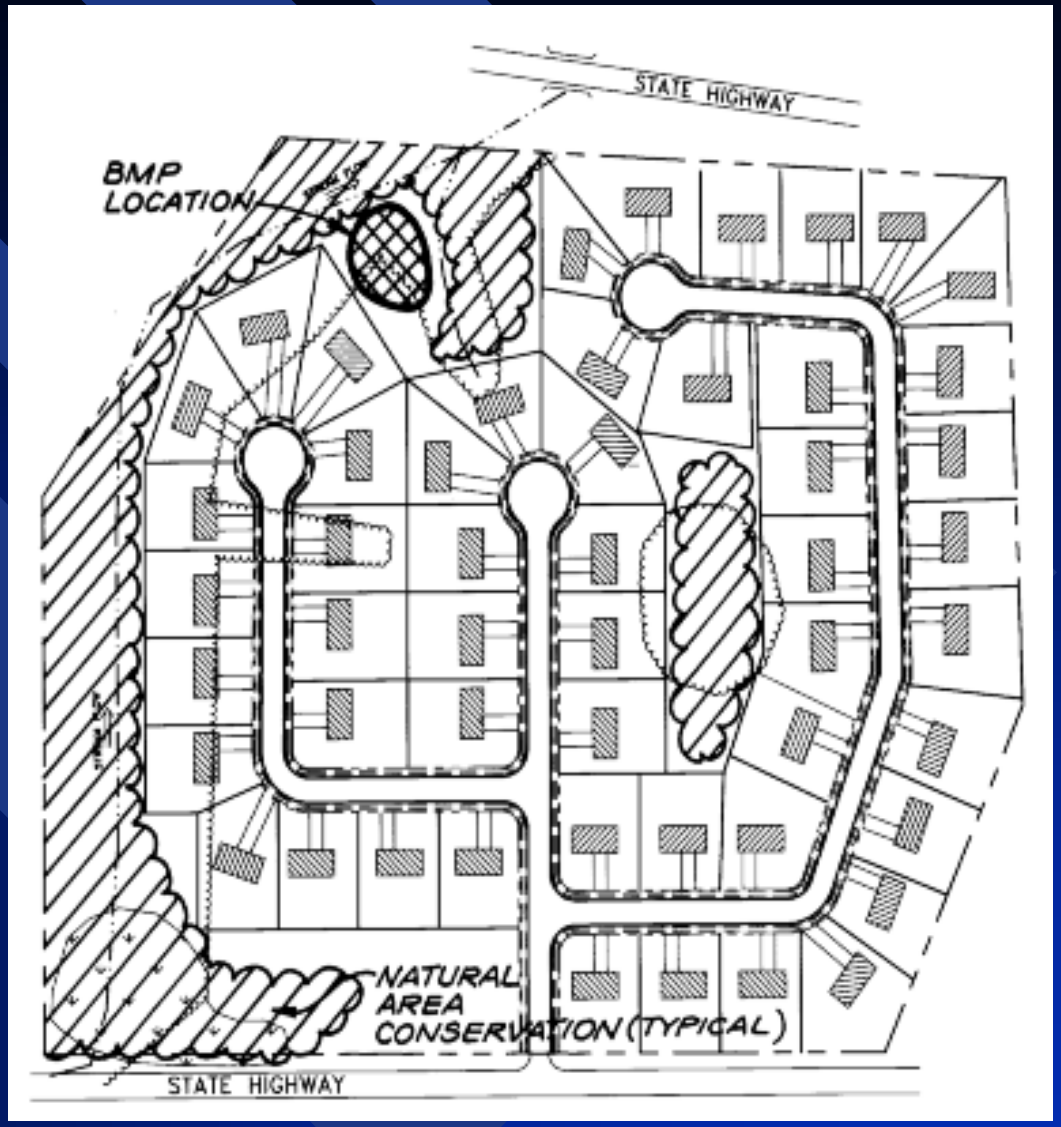
$WQ_v$ = (1.2 in) (0.32) (7 ac)/12 = 0.22 AF

(30% reduction in water quality volume)

Site Data - 51 Single Family Lots
Area = 38 ac.
Conservation Area = 7 ac
Impervious Area = 13.8 ac
$R_v$ = .38
Original $WQ_v$ = 1.50 ac-ft.

Computation of Credits
$WQ_v$ = 1.25* (.38) (38.0 - 7.0) ac. (1 ft/12″)
= 1.23 ac-ft

(18% volume reduction)




Note: 1.25” used here

# Element V
# Site Layout and Design

Now that the credits and volumes have all been calculated, the preliminary design of BMPs and conveyance takes place.

This involves:

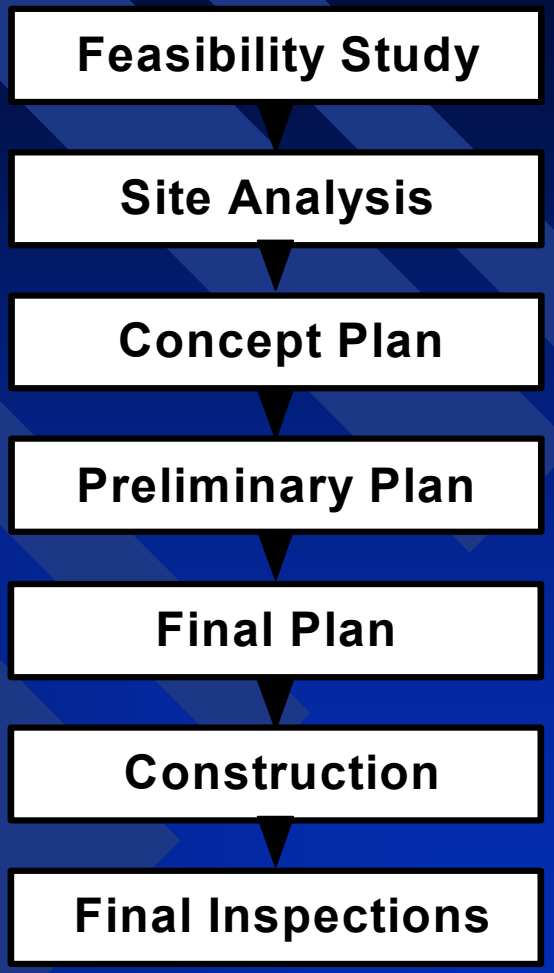
(1) integrating site and watershed demands

(2) screening BMPs

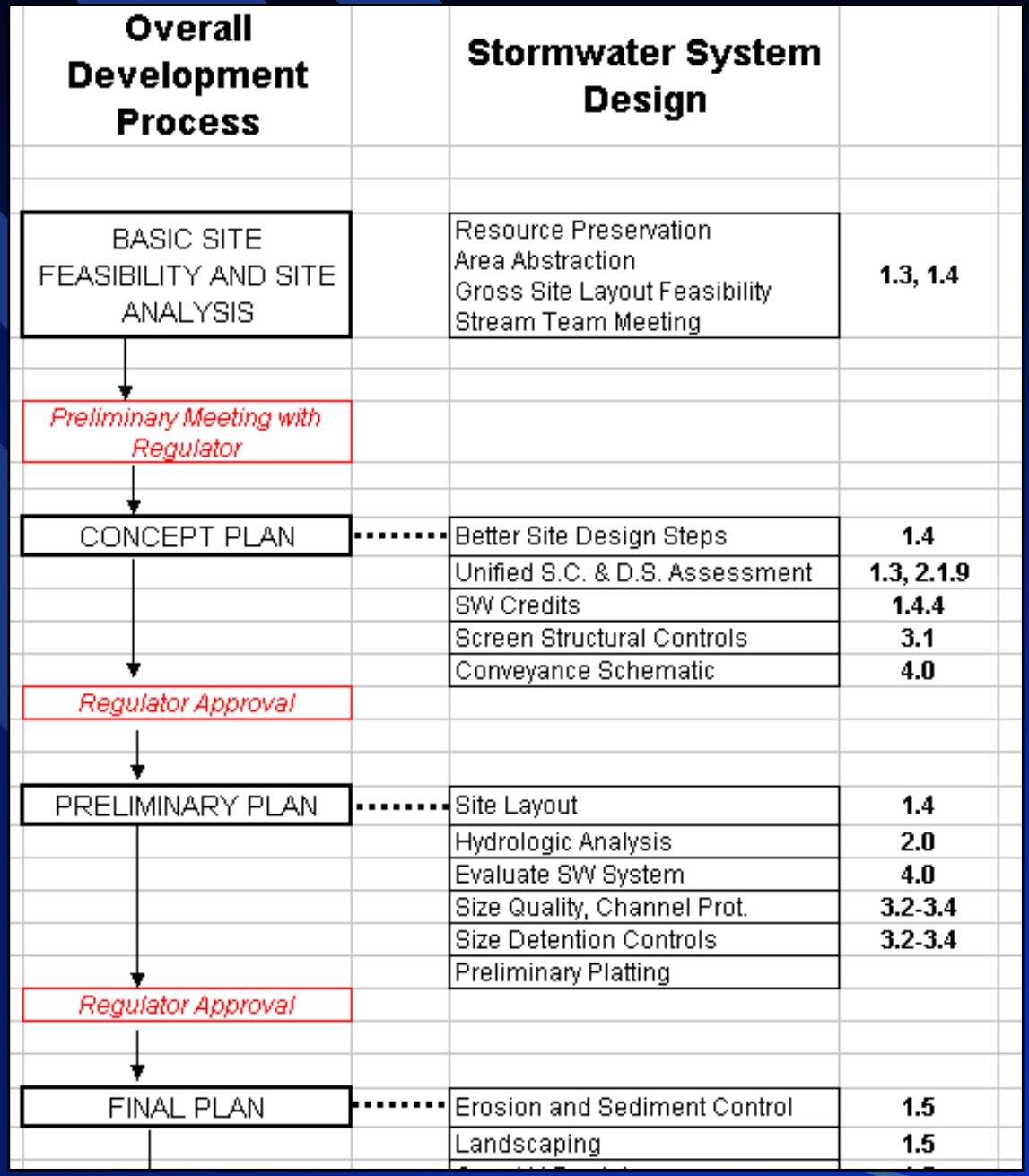
(3) calculating conveyance sizes & locations

# Site Development Process

- Early idea of requirements
- Take advantage of opportunities
- Involve local government earlier
- Rationally match level of effort to design stage



# Site development process tied to the iSWM manual for easy use and application



| Overall Development Process | Stormwater System Design | |
|---|---|---|
| BASIC SITE FEASIBILITY AND SITE ANALYSIS | Resource Preservation<br>Area Abstraction<br>Gross Site Layout Feasibility<br>Stream Team Meeting | 1.3, 1.4 |
| *Preliminary Meeting with Regulator* | | |
| CONCEPT PLAN | Better Site Design Steps | 1.4 |
| | Unified S.C. & D.S. Assessment | 1.3, 2.1.9 |
| | SW Credits | 1.4.4 |
| | Screen Structural Controls | 3.1 |
| | Conveyance Schematic | 4.0 |
| *Regulator Approval* | | |
| PRELIMINARY PLAN | Site Layout | 1.4 |
| | Hydrologic Analysis | 2.0 |
| | Evaluate SW System | 4.0 |
| | Size Quality, Channel Prot. | 3.2-3.4 |
| | Size Detention Controls | 3.2-3.4 |
| | Preliminary Platting | |
| *Regulator Approval* | | |
| FINAL PLAN | Erosion and Sediment Control | 1.5 |
| | Landscaping | 1.5 |

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# Two BMP Categories

- General Application
  - ✓ Ponds
  - ✓ Wetlands
  - ✓ Sand Filters
  - ✓ Bioretention
  - ✓ Enhanced Swales
  - ✓ Infiltration Trench
- Limited Application
  - ✓ Filter strip
  - ✓ Grassed channel
  - ✓ Organic filter
  - ✓ Underground sand filter
  - ✓ Submerged gravel wetlands
  - ✓ Oil-grit separator
  - ✓ Porous pavement
  - ✓ Paver blocks
  - ✓ Alum treatment
  - ✓ Proprietary systems

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**Table 4.7-1** Suitability of Structural Stormwater Controls to Meet Unified Stormwater Sizing Criteria

| Structural Stormwater Control | Water Quality Volume ($WQ_v$) | Channel Protection ($CP_v$) | Overbank Flood Protection ($Q_{p25}$) | Extreme Flood Protection ($Q_f$) |
|---|---|---|---|---|
| ***General Application*** | | | | |
| Stormwater Ponds | ✓ | ✓ | ✓ | ✓ |
| Stormwater Wetlands | ✓ | ✓ | ✓ | ✓ |
| Bioretention Areas | ✓ | ϑ | ● | ● |
| Sand Filters | ✓ | ϑ | ● | ● |
| Infiltration Trenches | ✓ | ϑ | ● | ● |
| Enhanced Swales | ✓ | ϑ | ϑ | ● |
| ***Limited Application*** | | | | |
| Biofilters | ○ | ● | ● | ● |
| Filtering Practices | ✓ | ● | ● | ● |
| Wetland Systems | ✓ | ● | ● | ● |
| Hydrodynamic Devices | ○ | ● | ● | ● |
| Porous Surfaces | ✓ | ϑ | ● | ● |
| Chemical Treatment | ✓ | ● | ● | ● |
| Commercial Systems | * | * | * | * |
| ***Detention Controls*** | ● | ✓ | ✓ | ✓ |

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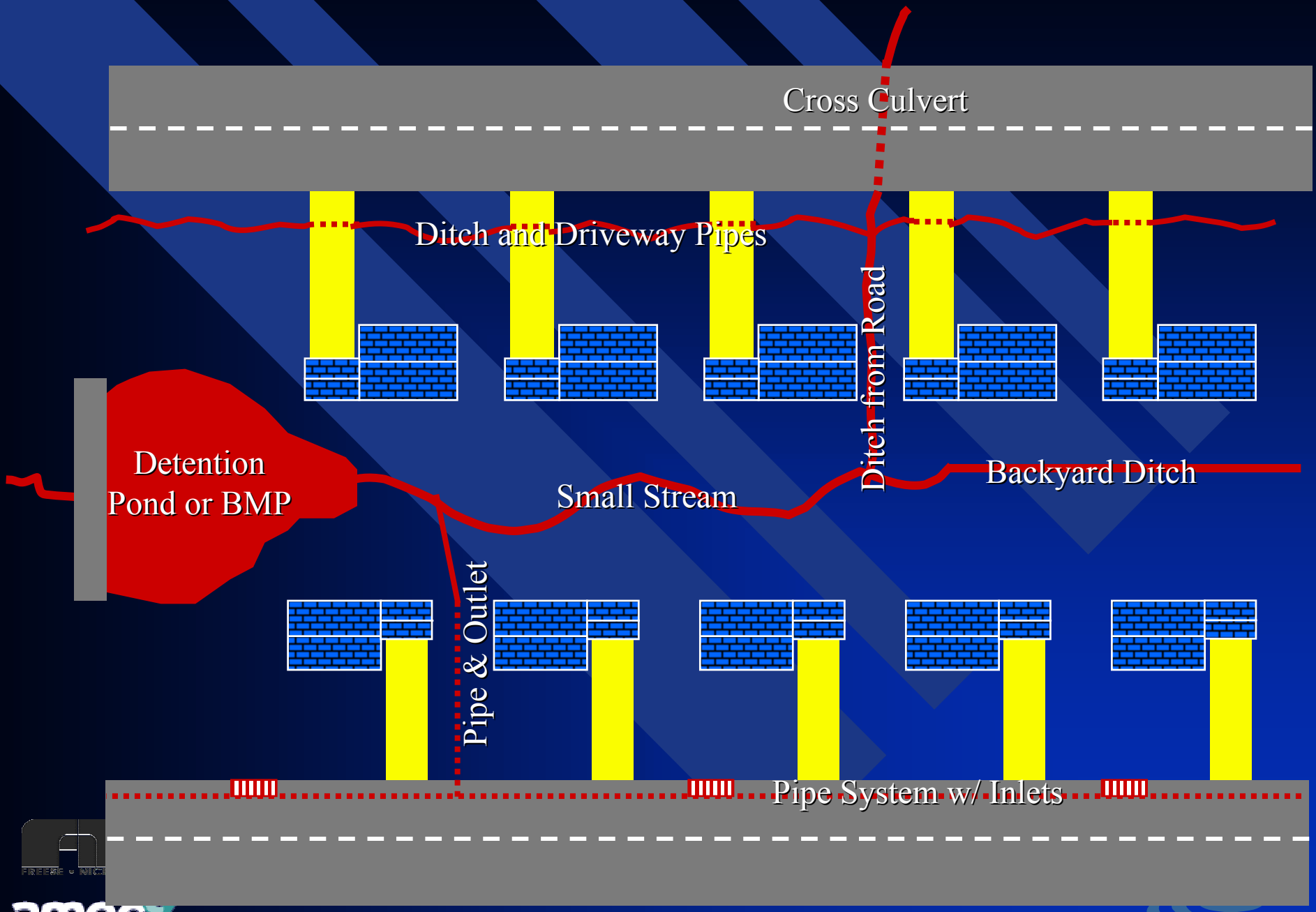
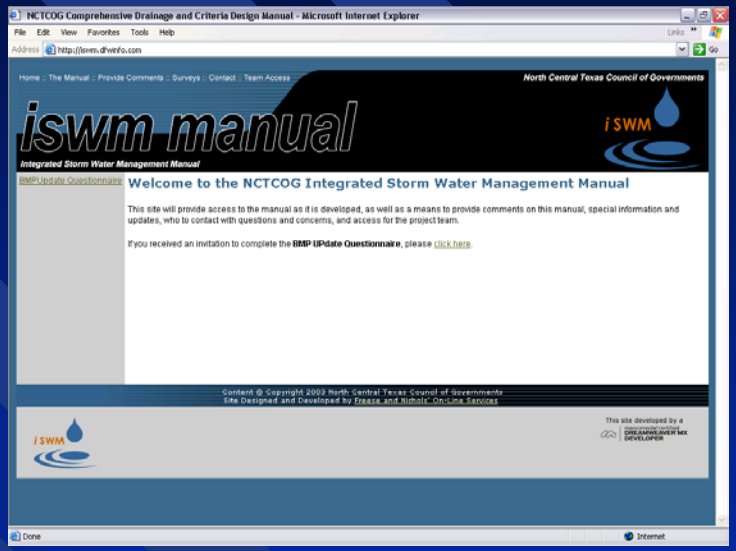
# Minimum Conveyance Design Guidelines

- **Minor System Design**
  - 10-year Storm
- **Major System Design**
  - 100-year Storm


Cross Culvert
Ditch and Driveway Pipes
Ditch from Road
Detention
Pond or BMP
Small Stream
Backyard Ditch
Pipe & Outlet
Pipe System w/ Inlets

# iSWM Website - Updates

- Draft Manual Sections for Review
- On-Line Comment
- Meeting Notices
- Project Status Updates
- Contact Lists

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